Vocational training in forestry. (*c*) Professional training in forestry.

The overstimulation of professional training whereby a much larger number of men of high educational attainments and thorough technical preparation are trained than are able to find professional employment is a waste and detrimental to forest conservation. On the other hand, secondary and vocational training can scarcely be overstimulated. It is the writer's opinion that the progress made in the actual conduct of forestry operations in the woods must center in a vast army with some training rather than full professional training, whose knowledge of forestry is chiefly confined to the art of forestry so far as it concerns their own locality and who do not look for, and should not expect, a wage beyond that which the operations justify.

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ON CERTAIN RELATIONS OF THE LOWER ANIMALS TO HUMAN DISEASE[1]

ONE of the striking tendencies in modern medicine has been an increasing apprecia-

[1] Read at the Quarter-Centennial of the University of Chicago, Departmental Conference in Pathology, June 6, 1916.

tion of the importance of the lower animals in relation to human disease. The subject is a vast one and may be discussed from many standpoints. Medically, animals may serve humanity or they may be directly responsible for terrible scourges. For experimental and teaching purposes in all departments of medicine they are indispensable and this forms one great field of usefulness for them. A second field is their use in the production of curative substances—serums, vaccines, ductless gland preparations, drugs, etc., a field which marks an epoch in modern medicine.

The relation of the lower animals to the transmission and causation of disease is another phase of this subject, but here the results, unlike those in the two fields above noted, are almost invariably serious for the welfare of man. In this field many great and interesting discoveries in recent years have been made. I shall limit myself to this topic and shall try to point out some of the more noteworthy features in this relationship and their bearing on preventive medicine.

Historically, in the very earliest accounts of primitive people, there are records concerning the relation of animals and animal parasites to the causation of disease. In Hirsch's classical work on geographical pathology we find a discussion of the records of the "fiery serpents" (probably the guinea-worms) that afflicted the Hebrews in their wanderings in the desert; and Plutarch narrates that "the dwellers by the Red Sea suffer from a serious malady due to a small serpent which issues from the skin to gnaw the arms and legs and retires underneath the skin if disturbed, causing the patient intolerable pain." Intestinal worms especially were well known to the ancients and form an important chapter in their medicine. In primitive peoples bites and lacerations by wild animals and snakes with the resulting secondary infections following such wounds gave rise to disease. Rabies was known over 2,000 years ago. It is of such a nature that its relation to dogs and other animals could easily be traced and this connection was well appreciated by the medical authorities in those times. Varro (116–27 B.C.) suggested that malarial fevers were transmitted by insects.

A landmark in the relationship of animal and human disease was the observations of Jenner in 1796 on the relation of smallpox and cowpox. The story is well known and need not be related here. It is a splendid example of careful observation, experiment and practical application even for our own day. Many of our most important modern problems—infection, immunity, prophylaxis, anaphylaxis, vaccination—have their beginnings here.

Coming now to the bacteriological era inaugurated by Pasteur during the latter part of the last century we note that the connection and interdependence between many animal and human diseases, though recognized before, became ever clearer and more definite. The work of Pasteur on animal diseases, especially anthrax and rabies, of Villemin on tuberculosis, of Koch on anthrax and tuberculosis, of Loeffler on glanders, of Bollenger on actinomycosis, may be mentioned in this connection. This was the era of great and numerous discoveries and the principles then established have directed and stimulated bacteriologic work to the present day.

Shortly after the advent of the bacteriological era there was superimposed upon this another era, that of protozoology. This may with propriety date from the discovery by Theobald Smith in 1889 of the causal organism (*Piroplasma bovis*) of Texas fever in cattle. A little later Smith and Kilbourne determined that the mode of transmission in this disease was by the cattle tick. The fact should be noted however that many years before, in 1864, Pas-

teur showed that the famous epidemic of silkworm disease in France was caused by a protozoan (*Glugea bombysis*) and this might be considered the first great discovery in this field. Another early discovery in protozoology was that of the malarial parasite by Laveran in 1880. These years, however, were so thoroughly dominated by bacteriologic conceptions that Laveran, thinking that the parasite belonged to the plant kingdom, gave it the name "oscillaria."

The significance of Smith and Kilbourne's discovery and what really marked a new epoch in the study of disease was the principle involved in the mode of transmission of an organism through infected ticks (and only in this manner) and in the fact that a definite series of changes necessary for the propagation of the disease went on in the body of the tick by the infecting agent. Here was an observation that opened a new field in the relation of animals to human disease and upon this basis the great discoveries in connection with the transmission of malaria, yellow fever and many other diseases, especially tropical, were later made. The mode of transmission in such diseases having thus become known their control in many instances has become a relatively simple matter.

To convey an impression of the importance and of the large number of diseases of man carried by the lower animals and as an introduction to a discussion of the varied relations of animals to human disease I will present the following résumé:

HUMAN DISEASES CARRIED

1. By the dog:
    - Rabies.
    - Foot and mouth disease.
    - Helminthiasis.
        - Flukes.
        - Tapeworms (especially *Tœnia echinococcus*).
    - Infantile splenomegaly (from dogs through fleas).
    - Trypanosomiasis (*T. gambiense*).
    - Mange.
    - Fleas and ticks.
    - Ringworm.
    - Favus.
2. By the cow:
    - Tuberculosis.
    - Actinomycosis.
    - Anthrax.
    - Cowpox.
    - Tetanus (through vaccine).
    - Foot and mouth disease.
    - Septic sore throat.
    - Rabies.
    - Pus infections.
    - Tenia saginata.
    - Milk sickness.
    - Paratyphoid fever.
3. By the horse:
    - Glanders.
    - Rabies.
    - Tetanus.
    - Sporotrichosis.
    - Anaphylaxis.
        - Serum disease.
        - Odor of horses.
4. By swine:
    - Trichiniasis.
    - Tuberculosis.
    - Anthrax.
    - Cestodes (especially *T. solium*).
    - Trematodes.
5. By sheep:
    - Anthrax.
    - Tuberculosis.
6. By goats:
    - Malta fever.
    - Tuberculosis.
7. By the antelope:
    - Sleeping sickness.
8. By the cat:
    - Rabies.
    - Cestodes.
    - Trematodes.
    - Favus.
    - Ringworm.
9. By rats:
    - Rat bite fever.
    - Bubonic plague (through fleas).
    - Trichiniasis (through hog to man).
10. By ground squirrels:
    - Bubonic plague.
11. By birds:
    - Psittacosis (from parrot).
12. By fish:
    - Tape worms.
13. By arthropods, chiefly insects:
    - Mosquitoes:
        - Yellow fever.
        - Malaria fever.
        - Dengue fever.
        - Filariasis.
    - Fleas:
        - Bubonic plague.
        - Infantile splenomegaly.
    - Ticks and mites:
        - Rocky Mountain fever.
        - Relapsing fever (African).
        - Tick fever of Miana.
        - Japanese flood fever.
    - Lice:
        - Typhus fever.

Relapsing fever (*Spirochæta obermeieri*).
Bed bugs:
Kala azar.
Flies:
Sandfly fever.
Sleeping sickness (tse-tse fly).
Typhoid fever and other infections carried mechanically.
Crustaceans (water flea):
Guinea worm infection (dracunculosis).
Oysters, clams, etc.:
Typhoid fever.
Snails:
Trematode infections (especially bilharziosis).

In this outline I have included the most important human diseases that in one way or another are wholly or to some extent dependent on lower animals for their existence and transmission. As given the list is not entirely complete, and if it were complete to-day it might not be complete to-morrow, so rapidly are discoveries especially in tropical diseases being made. The rôle that lower animals play in the transmission of intestinal parasites, for example, is exceedingly varied and though a prodigious number of these parasites have been described and their hosts and intermediate hosts determined there are still very many about which little or nothing is known. In the outline as given I have mentioned only some of the more important examples in this great group.

I wish now to briefly analyze some of the relations of the lower animals to human disease transmission. We find these relations in certain instances to be very simple, in other instances extremely varied and complex. The direct portals of entry into man are usually through the skin, the respiratory and the gastro-intestinal tracts. In some diseases transmission can occur in only one way. In others the transmission may take place in a great variety of ways. I will first group and summarize the modes of transmission as follows:

I. Infection in man may occur through simple contact with diseased animals. Excretions from lesions of skin, nose, lungs and intestines are the usual vehicles. As examples we may cite glanders, anthrax and cowpox. Previous wounds of the body surface may or in some cases may not be necessary for the transmission. The virus also may enter the body through the respiratory or gastro-intestinal tracts. While often this method of transmission is simple and direct, at times the virus may be carried long distances in very indirect and circuitous routes from the animal to man. This is particularly true of the spore-bearing organisms. Recently an outbreak of several cases of anthrax occurred in England which after considerable difficulty was traced to the use of infected shaving brushes. The anthrax bacilli were recovered from the used brushes as well as from new brushes from the same stock obtained in a store. They were made with hair from a diseased animal.

II. The infectious agent may be carried mechanically from person to person or from animal to person through food or otherwise by a second animal; as in the transmission of typhoid, dysentery, cholera, etc., by flies. Foot and mouth disease is said to be carried over long distances by dogs. Oysters thus transmit typhoid.

III. The animal may through a bite produce a lesion into which the infectious agent is transferred, as in rabies and especially in the blood-sucking insect diseases. Rat-bite fever, which according to the recent work of Hektoen and Tunnicliffe may be caused by the streptothrix of rat pneumonia entering the wound caused by the bite of the infected rat, would be here included.

IV. The parasite may be transmitted to man through the meat of lower animals used as food. It is possible though rare for certain bacterial diseases like tuberculosis and perhaps paratyphoid fever to be

transferred to man from the cow in this way. Tapeworm infections of various kinds are thus transmitted from a number of lower animals.

V. The infectious agent may be transmitted to man through the secretions of the lower animals. Here are included some of the most important and serious of human diseases. Malta fever is transmitted largely in this way through the milk and urine of goats infected with *Micrococcus melitensis*. The malarial parasite is transmitted to man by the anopheles mosquito through its salivary gland. Tuberculosis especially in children is often transmitted from the infected cow through the milk. In this connection the epidemics of streptococcus sore throat are interesting. Over thirty milk-borne epidemics of this infection have been reported and from the recent work of several investigators it would seem that in some instances virulent streptococci of the human type may find their way into the udder of the cow through the contaminated hands of the milker and there multiply and return subsequently in large numbers in the milk and infect the consumer. Some of these epidemics and perhaps many of them have originated thus. Capps and the writer several years ago and more recently Mathers have shown experimentally that virulent human streptococci when placed on the abraded teat of a cow will ascend the canal and infect the udder; or when injected directly into the udder will continue to multiply there, causing a mild or even a severe mastitis lasting for several weeks or for months. The streptococci in large numbers will pass out in the milk during this period and will retain their initial virulence for animals. Other kinds of infections may be transmitted in this way though perhaps rarely. True diphtheria bacilli, for example, have been isolated by Dean and Todd from the ulcerated teats and from the udder of a cow supplying families in which a diphtheria outbreak occurred.

Milk is such an universal food for both men and bacteria that it has been the vehicle for the transmission of many of the infectious diseases. In the outline given I have not mentioned the diseases which may be transmitted through milk, the virus having entered the milk after leaving the cow. In such infections the animal is not concerned directly in the transmission but only indirectly through its product.

VI. The infectious agent may enter one of the lower animals in which it passes through a regular phase or completes a cycle and then, usually through a bite of the animal, is transmitted to man. This mode of transmission concerns many of the protozoan diseases. We may group such infections under two heads: (*a*) those transmitted from man to man by a lower form, examples of which are the malarial parasite in the anopheles mosquito and the yellow fever virus in the stegomyia mosquito; and (*b*) those transmitted from an animal to man by one or more of the lower forms, illustrated by the transmission of *Trypanosoma gambiense* from the antelope or from the dog or the monkey to man through the tse-tse fly. In this case one or more of the lower animals are concerned in the transmission of a second animal, the parasite, to a third animal, man. Both (*a*) and (*b*) may occur in the same disease. The principle of host and intermediate host here involved is a very important one and numerous examples might be given. Many of the intestinal parasites, the entozoa, pass a part of their cycle of development in a lower animal. Most interesting relationships exist in this connection between some of the nematoda and the trematoda or fluke infections in man and certain small water animals, including crabs, snails and other arthropods. For example the guinea-worm,

a filarial parasite in man, lives in the tissues and at times the female bores outward through the epidermis, discharging the embryos which, if they find water, swim about and enter a small crustacean, the waterflea or cyclops, in which they remain for several weeks undergoing certain transformations. Finally they may enter the stomach of man through drinking water and then bore through the stomach wall into the tissues again. The liver fluke, common in sheep causing the disease "sheep rot" and occasionally found in man, uses several varieties of snails as hosts passing through certain rather complex changes and later leaving the snail to become encysted on grass or weeds which are eaten by sheep.

Through the recent work in Egypt of Colonel Leiper and his associates in the Royal Army Medical Corps it seems now to be firmly established, contrary to the views of Looss, that the fluke, *Schistosoma hœmatobium,* the cause of bilharziosis, after leaving the body in the urine uses the snail as an intermediate host in which it undergoes a metamorphosis before it is capable of infecting another person. Infection with the fluke actually takes place both by mouth and through the skin of the individual. It has been shown that eradication of this very prevalent and serious disease in the Orient will depend upon the destruction of snails, the cooperation of the infected individual not being necessary.

This résumé in a general way I think includes the modes of transmission of at least most of the human-animal diseases as we at present know them.

I wish now to call attention to a number of points which are frequently of great importance in the control of many of these diseases. For convenience of presentation I will mention them under four heads:

1. A lower animal may be the only agency in the spread of a disease. In malaria the available evidence indicates that the disease is spread only by the anopheles mosquito, although several varieties of this species harbor the parasite. So also yellow fever is spread, so far as we now know, only by the stegomyia mosquito.

2. Several different species of lower animals may be concerned in the transmission of the disease. As examples we may cite rabies which is transmitted by dogs, cats, wolves, horses and other animals; anthrax by sheep, cows, etc.; bubonic plague by rats and ground squirrels. The question as to whether a given disease is transmitted by one animal only or by several is so important so far as control measures are concerned that I need only pause to mention it.

3. The lower animal may be a "healthy" carrier. That is, the infectious agent though perhaps highly virulent to man may not cause the animal to become sick. A striking example of this condition is the Malta fever infection (*M. melitensis*) in goats. Malta fever, a human disease very common in Mediterranean countries and now prevalent in our southwest, is spread through the milk of goats. In most of these animals there are no symptoms whatever, the micrococcus being found in the milk or urine or blood of animals perfectly healthy and which remain so. Typhoid bacilli may live in the intestinal canal of flies. Tetanus bacilli may live for months in large numbers in the intestinal canal of horses, certain of these animals becoming virtually tetanus "carriers."

4. The lower animal may be a diseased "carrier"; that is, the infectious agent may cause the lower animal to become sick. Glanders in horses, rabies in dogs, anthrax in sheep are examples. This matter of degree of reaction or the severity of the disease in the animal is of very great importance in the control of the disease. From the standpoint of man's welfare it is often highly advantageous that the infection in

the animal should not only show symptoms but should be rapidly fatal so as to remove the source of danger as soon as possible. Malta fever is a very different disease to control because the goats so often show no clinical symptoms. Also a chronic disease in animals is a source of danger for a long period of time whereas the acutely fatal diseases terminate the danger quickly. Chronic glanders in the horse as compared with acute glanders illustrates well this point. Furthermore by the death of the animal in the rapidly fatal diseases usually the more highly virulent and hence the more dangerous strains of microbes are destroyed at the same time.

Usually the natural animal diseases transmissible to man are deleterious to him. Occasionally a natural animal disease has been made to serve a good purpose by furnishing a means for protective inoculation in man. Cowpox is an example, the natural virus being continued in the cow and then transferred artificially to man for protective purposes against smallpox. The Pasteur treatment in hydrophobia depends on much the same principle, the virus being propagated however in another animal, the rabbit, the spinal cord of which is then artificially inoculated into man for preventive purposes.

As a result of the use of animal products for protective and curative purposes in medicine, there is produced at times the condition of anaphylaxis known as "serum disease." This reaction is so serious that it may actually interfere with the use of serums over long periods of time in the treatment of chronic disease. The success of serum therapy has so far been confined largely to acute diseases which ordinarily do not require long treatment, so that the danger of anaphylactic shock has not in this respect seriously restricted the use of serums. In this connection might be mentioned the state of certain individuals who are hypersensitive perhaps naturally to the odor of horses and when near the animal manifest definite symptoms of an anaphylactic character.

Certain diseases common in animals and man exist in which there is little or no evidence that man is infected directly from the animal. Actinomycosis is such a disease. It is doubtful if there is a case on record in which man became directly infected with the actinomyces through contact with a diseased animal. Sporotrichosis likewise is common in horses and in man, but there is but one or two cases where direct infection occurred and this was through the bite of a horse. In such diseases the animals are dangerous not so much through direct contact as through the general dissemination of the microbes upon soil, grass, fodder and various objects, thereby greatly increasing the opportunity for human infection in a variety of indirect ways.

While man receives a large number of diseases from or through the lower animals, if we inquire into the reverse proposition, we find that any one of the lower animals though suffering on the whole from many diseases, acquire relatively few from other animals including man. The horse, for example, receives rabies from dogs, and occasionally anthrax from sheep and cows. Tuberculosis hardly exists in this animal. In the tropics it has its diseases carried by flies and ticks though they apparently are not as numerous as the human diseases so transmitted. The cow appears to be somewhat more susceptible to diseases from other species than is the horse but apparently not as susceptible as man to such. The dog and the other animals enumerated, all have a host of their own diseases, relatively few of which seem to depend on some other animal for their transmission. Exception might be taken to this statement concerning the lower animals. It may be that it

only appears to be true because we know more about the diseases of man than those of the lower animals.

Certain reasons may be here enumerated why man is subject to at least many of the animal diseases. Man is commonly concerned in caring for sick animals and some diseases, like glanders, are commonly transmitted in this way to veterinarians, hostlers and teamsters. The demand of the human for animal pets and the social demands of certain types of humanity for dogs, cats and other animals living in intimate association with them explains the origin of certain diseases, especially those parasitic in character. Man lives largely on meat and other animal products, many of which are uncooked or improperly cooked. Man uses animals in a variety of ways in the industries, the relations being often such as to necessitate intimate contact. Again, wild animals are free from many diseases but domestication or confinement by man may make them highly susceptible. Such animals then may become a source of danger to man and thus a vicious circle is established.

The transfer of certain diseases from animals to man is, under existing conditions, not a reversible process. Rabies is commonly transmitted from dog to man but practically never, so far as we know, in the reverse direction. This is true of many diseases and depends upon such factors as the superior care given to the human sick and the methods of isolation.

It would seem then that man's relations and points of contact with a large variety of the lower animals are more intimate and complex than those of any of the other animals to other species and as a result of such relations, on the whole, the disease transmission from animals to the human is naturally increased in number and variety. This is one of the penalties that man pays for being nurse, doctor and master of the brute creation.

While animals play such a very important rôle in the transmission of disease to man it is interesting to note that plants play practically no rôle whatsoever in this regard. Though plants are afflicted with microbic and fungous diseases to an extent probably even greater than are animals, only one organism is known which is apparently pathogenic for both plants and man. According to the work of Johnston,[2] cocoanut budrot, a disease of the cocoanut common in Cuba, is caused by an organism practically identical with *Bacillus coli* (Escherich) Migula. Inoculations into cocoanut seedlings with *B. coli* of animal origin give infections similar to inoculations with the cocoanut organism. It may be stated, however, that this plant disease is of no significance, so far as we know, in the transmission or the causation of human disease, since *B. coli* ordinarily does no harm when taken into the alimentary canal. It is true, of course, that many plants carry disease germs such as typhoid and dysentery bacilli mechanically upon their surface where they may remain alive for some time and in this respect play a rôle comparable to that of flies in the transmission of typhoid fever.

The higher plants being so remote biologically from the higher animals it is improbable that specific disease germs pathogenic to these two types of organisms will be found. However it is possible that plants may be found which serve as intermediate hosts for organisms not pathogenic for them but pathogenic for certain animals. Many of the viruses and parasites which cause disease in man use some lower form of animal biologically far removed from man for a certain period of their de-

[2] "The History and Cause of the Cocoanut Budrot," Bull. No. 228, Bureau of Plant Industry, 1912.

velopment, but do not cause symptoms in this animal. The malarial parasite and the yellow fever virus do not seem to injure the mosquito. Nor does the virus of Rocky Mountain fever injure the tick or that of typhus fever the louse. There is, as we know, some degree of parallelism between biological relationship and susceptibility to a given virus. But this susceptibility has nothing to do necessarily with the ability of an animal to serve as an intermediate host or to harbor a parasite.

The question of adaptation in this connection should be mentioned. It is a problem which for a long time has interested the bacteriologist, but by none has its importance been more clearly grasped than by Pasteur who was influenced so decidedly in his experimental work on animals by this principle. In the relation of disease to animals most of the important points center around this fundamental idea in one form or another. It goes hand in hand with the principle of specificity. A given organism supposedly specific for a given animal may acquire the property by adaptation of growing in the body of another animal. It has widened its sphere of activity in certain respects but in other respects it is as specific as ever. Specificity like immunity is a phase of the principle of adaptation. In the study of human-animal disease we note that some organisms naturally are adapted to grow in a variety of animals, others limited very decidedly to a particular animal and even to a particular race of a given species. By experiment these latter may be made to widen their sphere of activity very appreciably. As specific illustrations I may cite the early contributions of Welch and the recent work of Gay and Claypole in causing the typhoid carrier state in rabbits; also the work of Culver in increasing by repeated transfers the resistance of the gonococcus to rabbit serum and the infection of rabbits with such a strain. Some strains of bacteria identical when tested by our most refined laboratory methods may be highly pathogenic for a given animal but non-pathogenic for even a closely related species.

As to the importance of such processes of adaptation in nature for the dissemination of disease from one variety to another or from animal to man, it is very difficult to obtain, experimentally or otherwise, definite data extending over a sufficiently long period of time to be of value. We can at present perhaps conceive of no better hypothesis for the origin of infections and their continuance. Bacteria are very old, there being definite evidence, as shown by B. Regnault and by Moodie of the existence of bacilli and cocci in the intestinal canal of animals (coprolytes), in decomposing plant and animal remains and probably also as disease producers in the Mesozoic and Pleistocene era ten to twelve millions of years ago. Far less change were necessary in the bacteria to develop into the types of to-day than have occurred in animals since that time.

There are many infectious diseases whose modes of transmission are at present obscure which no doubt will be found to be carried by some lower animal form. As an example of such may be mentioned Rocky Mountain tick fever, in which suggestive evidence exists of a relation to some wild animal, possibly the gopher (spermophilis), as a tick-carrier. The work of Strong and his associates on the two South American diseases, verruga peruviana and oroya, would indicate that they are transmitted by some arthropod. This has not yet been demonstrated. The modes of transmission of many trematode and nematode infections have not yet been discovered, but from what is known of such diseases there can be little or no doubt that many are transmitted through another animal. Infantile paralysis has been transmitted ex-

perimentally from animal to animal by flies but it has not yet been shown that flies play a significant rôle in human transmission. As to the fly it is difficult to determine how important it is in the transmission of a number of infections.

While much suggestive evidence exists concerning the rôle of animals in carrying certain diseases whose origin is still obscure, on the other hand, there is in the literature much loose speculation as to the rôle animals play in many such diseases. Superstition and tradition enter at times to aid this speculation. The older literature contains many articles on the rôle of dogs, cats, and other domestic animals in the transmission of the various contagious diseases, especially diseases of children. Syphilis, measles, scarlet fever, smallpox, etc., have been thought to be transmitted by lice, bed bugs, flies and other bloodsucking insects. Occasional instances of such modes of transmission have perhaps occurred or are possibilities, but there have been much worthless discussion and speculation on these subjects.

In the solution of the various problems that arise in connection with prevention of human-animal diseases no one rule can be established for their control. In the first place each disease must be studied by itself and its natural history in detail should be known in order to intelligently cope with it. Upon personal hygiene and care in all matters concerning diet, clothes, housing conditions and our relations to animal life as well as upon close observance of sanitary rules will largely depend the solution of these problems.

As already stated nearly all of these diseases are easily preventable once the true natural history of the disease is known. The serious problem then is usually the education of the public. To illustrate, in hydrophobia prevention centers around the problem of the muzzling of dogs. This has been known for decades, yet the American people prefer to have 5,000 persons, mostly children, bitten each year and a hundred or more deaths, than to subject their dogs to the discomfort of a muzzle and to destroy the stray and worthless curs of the street. It should be said that this has been true in the past. Now the problem has become far more serious. In our western states rabies has spread during the past year to the coyotes, wolves and other wild animals which wander about biting domestic animals, especially stock, and even attacking persons, particularly school children. Our government has now spent large sums in an attempt to control the disease, but, once in wild animals, it is known to be very difficult to eradicate. Thus the matters stand at present with this human-animal disease. Such an experience should serve as an example, and many others might be given, in this matter of the importance of animals to human diseases and their control.

The study of comparative pathology, it would seem, should occupy a more prominent place in the curricula of our universities and medical schools than it has in the past. When we consider the fundamental character of the studies in this field of pathology—the work of Jenner, of Pasteur, of Koch, of Theobald Smith and especially of a great group of investigators in recent years on cancer and on tropical diseases in man and animals—the truth seems evident that in the study of disease and in its presentation to students such an important field should not be slighted. Our study of disease in medical and veterinary institutions should be at least as broad and as comparative as is the study of zoology or botany. In order to understand the natural history of many diseases comparative studies are absolutely necessary. It would undoubtedly be advantageous both from a humane as well as from a scientific

standpoint if our medical schools and hospitals, our veterinary hospitals and even our cat and dog hospitals and other places for the care of sick animals could all be concentrated in one institution for the broad study of disease. This indeed is now being attempted in certain institutions and no doubt will result in a broader conception of pathology.

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INVESTIGATIONS AT THE WOODS HOLE BIOLOGICAL STATION OF THE UNITED STATES BUREAU OF FISHERIES

THE laboratory of the Woods Hole Biological Station of the United States Bureau of Fisheries opened for the season's operations on June 19, under the directorship of Dr. P. H. Mitchell of Brown University. The various investigators are: Dr. W. W. Browne, of the College of the City of New York, who is studying various phases of bacteriology of fishes including bacterial changes during cold storage and the occurrence of pollution bacteria in food fishes; Dr. I. A. Field, of Clark University, who is completing a comprehensive report on the biology and economic value of the sea mussel and is conducting investigations on its embryology; Dr. C. W. Hahn, of the New York City High School of Commerce, who is studying sporozoan parasites of fishes with especial reference to modes of infection; Dr. Edwin Linton, of Washington and Jefferson College, who is studying fish parasites and the food of certain fishes; Dr. Sergius Morgulis, formerly of the College of Physicians and Surgeons, who is continuing researches on the metabolism of fishes; and Dr. G. G. Scott, of the College of the City of New York, who is studying the oxygen requirements of various marine forms and the oxygen consumption of developing fish embryos. The scientific assistants are: Mr. A. E. Barnard, of Brown University, who is working with the director on the nutrition of oysters; Mr. R. L. Barney, of Brown University, who is aiding the director in the study of diatoms of green gill oysters and the life history of sporozoan parasites; Mr. F. R. Dieuaide, of the College of the City of New York, who is assisting Dr. Scott and is making a collection of Woods Hole marine flora; Mr. E. W. Fuller, of Amherst College, who is assisting Dr. Morgulis; and Mr. K. S. Rice, of Brown University, who is assisting the director in the study of the food supply of oysters.

The facilities of the laboratory have also been extended to the following table applicants: Dr. N. A. Cobb, of the Department of Agriculture, and the Misses Cobb and Mr. Alfred Steinberg, who are assisting Dr. Cobb in the study of the physiology of nematodes; Dr. S. A. MacCallum, of New York City, who is investigating fish parasites, especially the helminthes; Dr. Albert Mann, of the Department of Agriculture, who is studying the diatom flora of the Woods Hole region; Dr. A. M. Reese, of West Virginia University, who is investigating light reactions of *Diemyctylus;* Mr. A. C. Redfield, of Harvard University, who is studying the melanophores of lower vertebrates especially in relation to adrenal glands of fishes; Mrs. A. C. Redfield, who is studying respiration in lamellibranchs; Dr. F. P. Reagan, of Princeton University, who is studying the development of *Fundulus heteroclitus;* and Mr. C. C. Speidel, of Princeton University, who is sharing a table with Dr. Reagan, and is investigating the function of certain peculiar cells of the spinal cord of the skate. The facilities of the laboratory will also be granted, during September, to Dr. F. C. Weber and assistants, from the Bureau of Chemistry, for investigations concerning copepods as food for sardines. The laboratory closes on September 15.

P. H. MITCHELL
WOODS HOLE, MASS.,
August 29, 1916

SCIENTIFIC NOTES AND NEWS

THE American Astronomical Society met in the Sproul Observatory, Swarthmore College,